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The Impact of ICT on Agricultural Extension Services Delivery: Evidence from the Rural e-services Project in India

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Summary

This study examines the impact of a mobile phone technology enhanced service delivery system on agricultural extension services delivery in India. An impact analysis is carried out based on randomised survey data taking into account of potential systematic selection bias through double difference techniques and reflexive comparisons. Findings from the research show that the amount and quality of the services and the speed of services delivery have been improved significantly as a result of the intervention. There are also indirect benefits from this ICT-enhanced services delivery system not only in greater awareness and knowledge in agriculture technology and information but also in terms of farmers' attitudes towards trying new technology and new ways of life in the future. Evidence from the evaluation suggests that disadvantaged farmers benefit more from this intervention than those who are better off.

Key words: Information and communication technology, agricultural extension services, impact analysis, India

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I. INTRODUCTION

Global attention came back to agriculture due to the price hike in recent years, resulting partly from long-standing negligence on diffusion of appropriate technology that stagnated production in the face of a rising population. Increasing production is a major challenge facing present agriculture. Smallholder farmers which dominate the landscape of developing world need to improve farming through acquiring adequate knowledge and information. Agricultural extension services provide critical access to the knowledge, information and technology that farmers require to improve the productivity and thus improve the quality of their lives and livelihoods. It is hence crucial to provide farmers with the knowledge and information in a quality and timely way. Although some ground-breaking tools like the telecenters can serve as major catalysts for information, knowledge and development opportunities, the access for farmers in remote villages is restricted due to the lack of infrastructure (UN, 2005).

Mobile phone penetration has been growing rapidly even in the remote rural areas. The unprecedented speed of adoption of mobile phone technology has raised the general expectations about its potential contributions to spread of innovative farming technology, as well as farmers' knowledge and awareness of other relevant knowledge and information. What is the impact of mobile phone technology on the agricultural extension services delivery? What is its wider impact on farmers' attitudes to new agricultural technology in the future? These are important questions that have not yet been fully explored. Moreover, although there have been some evaluation studies of its impact, the normal assessment method is often subject to serious selection bias (Heeks and Molla, 2009). Finally, in addition to the normal question regarding the impact on the speed, quality and volume of services delivery, it is also important to understand the influence of the experience on farmers' knowledge of agricultural technology and their attitudes towards future adoption of new technology. To our knowledge, so far there is no large survey data-based evidence on the impact of

ICT on agricultural extension services delivery in remote areas probably due to the lack of reliable data on outcome variables, as well as variations across extension and non-extension communities and between users and non-users in observable and unobservable factors (Aker, 2010). The pioneering studies of Jensen (2007) and Aker (2008) focus on the impact of mobile phone technology on price services provision for fishers and in the grain market.

This paper attempts to assess the impact of mobile phone technology on rural services delivery based on an evaluation of an UK Engineering and Physical Science Research Council (EPSRC) funded 'Knowledge Help Extension Technology Initiative' (KHETI) project in India. In particular, this paper investigates to what extent such technology can help farmers gain agricultural knowledge, create awareness among them on new practices and technology, and whether such technology has been effective in delivering quality and speedy extension services as expected. The assessment uses a purposely designed randomised survey data consisting the population of the treatment group as well as a control group, comparing not only the differences between the treatment and the control group, but also the changes before and after the intervention. The paper contributes to the literature by adding the first empirical evidence on the impact of mobile phone technology on agricultural extension services delivery. It also demonstrates the effect of such ICT-assisted new experience on farmers' attitude and aspiration towards future new technology adoption.

The remainder of this paper is organized as follows. Section II briefly discusses literature on extension services delivery and evaluation. Background of the study including the context in India and the KHETI project are discussed in section III. Methodology including evaluation design, sampling strategy and data collection approach as well as impact indicators and analytical framework is explained in section IV. Section V presents the results. Section VI concludes.

II. LITERATURE REVIEW

Agricultural extension services include transferring knowledge to farmers, advising and educating farmers in their decision making, enabling farmers to clarify their own goals and possibilities, and stimulating desirable agricultural developments. Traditional public-sector extension services use a variety of extension programmes to overcome barriers to technological adoption without much success (Anderson and Feder 2004, Anandajayasekeram et al. 2008, Aker 2010). Historically, agricultural service delivery in developing countries started with production-oriented limited extension services for export crops. The attention was diverted in the fifties to food production and improved farming techniques (Anandajayasekeram et al. 2008). In the 1960s US-led 'technology transfer model' employed a large number of extension agents to provide extension services. Since then, with the rise in the demand for agricultural services, many variants of approaches, models and methods have been evolved to connect researchers, extension agents, producers and consumers (Leonard 1977; Garforth 1982; Feder, Just and Zilberman 1986; Axinn 1988; Anderson and Feder 2004). The World Bank sponsored Training and Visit (T&V) extension model, Farmers Field Schools (FFS) and fee-for-services are the most common approaches. In the T&V and FFS systems, extension workers passed information to selected contact farmers who shared information with other farmers (Anderson and Feder 2004). It is widely accepted that extension services are an important element within the array of market and nonmarket entities and agents that provide human capital-enhancing inputs, as well as flows of information that can improve farmers' and other rural peoples' welfare. However, these services delivery models are also subject to criticisms, for example, poor and marginalized farmers in remote villages remain beyond the reach of appropriate services.

It is widely expected to be a useful tool contributing to development around the world (UNDP, 2001; Friedman, 2005). It is found that ICT allows efficient and transparent storage, processing and communication of information and that entrepreneurial innovation in this field may affect economic and social change (Kaushik and Singh, 2004). Growth in ICT investment is also found to be positively associated with growth in both GDP and productivity in Asia-Pacific countries for the period 1984-1990 (Kraemer and Dedrick, 1994).

It is increasingly recognised that ICT is necessary for accessing required information and knowledge (Richardson 1997; Chapman et al. 2004; Anandajayasekeram et al. 2008; Mcnamara 2009; Aker 2010). ICT kiosks, ICT-equipped intermediary organisations and mobile phones are expected to play an important role in strengthening the more complex and time-urgent pathways of information and knowledge-sharing on which agricultural innovations depend. According to Meera et al. (2004), ICT would enable extension workers to gather, store, retrieve and disseminate a broad range of information needed by small producers such as information on best practices, new technology, better prices of inputs and outputs, better storage facilities, improved transportation links, collective negotiations with buyers, information on weather. A workshop organised by the World Bank found ICT was underutilised in extension services delivery and hence the need to support policy environments and programmes that use ICTs (Alex et al. 2004). Moreover, Heeks and Molla (2009) find in their ICT evaluation compendium that ICT is not fully utilized in agriculture. Scaling up of delivery still remains at experimental stage. Although farmers have the real need to access to market information, land records and services, accounting and farm management information, management of pests and diseases, rural development programmes and ICT could help accessing these services, ICT projects dealing such services are extremely limited (Meera et al., 2004). Poor, marginalised and illiterate farmers and females are excluded, and marginal areas are excluded. Staffs for agricultural extension projects have inadequate training and farmers have very little faith in the ICT project personnel and their commitment to achieve the goals of the projects (Meera et al., 2004). However, research on how the excluded farmers could be reached is limited.

Mobile phone technology has been diffused rapidly in the rural areas of the developing countries in recent years. It has the advantage over other ICT tools in terms of its appropriateness for the under-developed local conditions. Other than mobile phones, other ICT tools suffers from the problem of feasibility for the poor in geographically disadvantaged areas because of lack of enabling environments such as infrastructure and capital. Internet enhanced technologies are not appropriate in the areas lacking electricity and network infrastructure. On the contrary, mobile phone technology has much less requirement on the infrastructure and hence wider applicability especially in mountainous areas. Mobile phones enable both audio and video functions which can meet most of the basic needs of the poor. It also has greater affordability for the farmers than internet. In many developing countries more than 80% population have access to mobile phones. Jensen (2007) demonstrated that the ICT helped fishers along the coastline in Kerala, India learn about prices at different locations and decide where to sell their products profitably. As a result, price volatility and variation dropped; producer prices rose and at the same time consumer prices dropped. Aker (2008) studied the impact of the mobile phone rollout on grain markets in Niger and show that mobile phone service has reduced grain price dispersion across markets by a minimum of 6.4 percent and reduced intra-annual price variation by 10 percent.

Of course, ICT is not always found to deliver its promise as expected. Chowdhury (2006) finds a negative effect of ICT investment on the labour productivity of East African small and medium-size enterprises, which is likely due to the low cost of labour relative to capital in East Africa which prevents substitutability being a profit maximizing approach. Moreover, a lack of knowledge of best practices in IT usage as well as IT-related skill deficiencies in the workforce will also constrain the benefits from ICT, as argued by Kaushik and Singh (2004) based on case studies of two projects in North India. The digital divide is not merely a problem of access to ICT, it is part of a larger developmental problem in which vast sections of the world's population are deprived of the capabilities necessary to use ICTs, acquire information and convert it into useful knowledge. Balanced growth is needed and deep structural problems must be solved to make ICT-induced development more inclusive (Parayil, 2005).

III. Background

Agricultural extension services delivery in India

India has been experiencing major changes in agricultural extension system since the 1990s (Rivera, Qamar, and van Crowder 2001; Birner and Anderson 2007; Anderson 2007, Raabe 2008). The reform included both demand and supply side measures. The demand side measures were the decentralization of extension service provision to the local level, the adoption of pluralistic modes of extension service provision and financing, and the use of participatory extension approaches. The supply side measures included civil service and public expenditure reform, training and capacity building, public-private partnership and utilisation of ICT for government services. Examples of initiatives are the World Bank funded Diversified Agricultural Support Project (DASP) and the National Agricultural Technology Project (NATP), Danida and IFAD funded gender focussed projects and the private sector e-Choupal initiative (Rabbe 2008). The public sector programmes are constrained by many factors including lack of transportation and communication and poor skills of service providers. Nevertheless, public sector reform has been continuing, for example, the "Support to State Extension Programmes for Extension Reforms" which aimed to help the states revitalize their extension systems for the agriculture sector. However, given the limited capacity of public extension services, it is not possible to reach the smallholder in remote areas without speedy technology that can easily reach the remote areas.

Private sector initiatives in the area of agricultural extension services delivery are extremely limited. Widely discussed initiative is e-Choupal, an ICT enhanced initiative of the Indian Tobacco Company.

The technologies depend on computers, internet and land line connections. The problems also include slow and disruptive internet connectivity, poorly maintained land lines, the unreliability of electricity supply and power backup systems and operational constraints from the inadequate maintenance and support of the equipment (Annamalai and Rao 2003). There are also some initiatives involved the establishment of information kiosks and information shops. Farmers are provided with information on crop technology and farmers' rights, loans, and the availability of grants (Singh 2006). However, the disadvantaged section of the population was still out of reach.

The KHETI project

The Agricultural Information Flow System titled ‘Knowledge Help Extension Technology Initiative’ (KHETI) was funded by the EPSRC and carried out by an interdisciplinary team including Oxford University, Sheffield Hallum University, the Overseas Development Institute and Sarah Services (a NGO in India). The primary objective of KHETI was to speed-up the communications amongst various stakeholders involved in the extension services delivery system. Stakeholders include agricultural scientists, agriculture communication specialists, communities and farmers. A primary component of the project was helping a NGO known as ‘Sironj Crops Producers Company Limited’ (SCPCL) with the KHETI. SCPCL is an association of poor and marginalised farmers in Madhya Pradesh. SCPCL aims to provide its members with information on agricultural techniques, market prices, and to enable them getting access to better markets for inputs and outputs. There were around 40 villages under each SCPCL office having only one agricultural expert. Huge travelling time and costs were involved and realistically it was not possible to satisfy the needs of all farmers. Farmers cannot travel in the peak seasons without affecting farming activities negatively. Farmers have a basic need for a system that can enhance the flow of the timely information at the door-step. The purpose of the KHETI project was to introduce an ICT enhanced solution to these problems.

Technologies used in KHETI are special mobile phones that are carried by '*Munnas*' who are the assistants to agriculture specialists travelling in the villages. The mobile phones are used to create Short Dialogue Strips (SDSs), which are audio visual creations on the local agriculture problem, issues and knowledge. An SDS includes a maximum of six images and two minutes of audio recording. In this system specialists do not need to visit farmers to know problem and answer queries and farmers do not need to physically visit specialists to report problems and get solutions. The *Munnas* can pass on any issue on crop and farming to an agricultural scientist on behalf of farmers and convey the solution to the farmers using the special mobile phones. Thus *Munnas* help farmers and agriculture experts to exchange queries and solutions through SDSs. This technology was designed and developed through participative design and agile programming method. Prior to designing the features a series of meetings and participatory exercises took place with the farmers to assess the needs. The project was located in Sironj Block (sub-district) of Vidisha district of Madhya Pradesh (MP) in Central India. Most of the people of the district are farmers. Main crops in Sironj are wheat, gram and maize in winters and soybean in rains. Though MP has the largest tribal population and particularly scheduled tribes, non-tribal population is concentrated in the central part of MP where Sironj is located. The services were free to the farmers.

IV. METHODOLOGY

(1) Measurement of impact

In this study we consider impact as the changes in extension services delivery in the project area due to an introduction of a mobile telephone based service provision. Put another way, we intend to measure the change in extension service delivery in the project area in relation to "what would have happened to extension services delivery" in absence of the newly introduced mobile phone based technology. The group, which contains the effect of an intervention, is called the 'treatment' group and the group, which is similar to treatment group but has not been exposed to the programme intervention, is known as the ‘control’ group or ‘comparison’ group. The purpose of the control group is to provide an estimate of what would have happened in absence of the intervention, this is called ‘counterfactual’. The counterfactual cannot be directly observed but must be approximated with references to a control group. Whether the estimated impact is ‘valid and generalizable’ depends on the evaluation design, which takes care of identifying the control and treatment groups as closely as possible. Once the groups are closely identified and the indicators are chosen, the difference in indicator variable between the groups would capture the robust impact of an intervention.

Mathematically, under the perfectly controlled experiment or randomisation, typical average impact could be expressed as follows (Rubin 1974, Ravallion 2008):

$$\bar{I} = \frac{1}{n}\sum_{i=1}^{n}(O_i^T - O_i^C) \qquad (1)$$

where I is “impact” (also known as “causal effect” or “gain”), O is the value of the interpretable impact indicator, T and C represent treatment group and control (comparison)[1] group respectively, i represents the sample units (in this study it represents the participants of KHETI project and non-participant farmers or farm household) and n is the sample size. In randomized experiment the average I is an unbiased estimator of the true impact, which is unknown because one of O^T and O^C remains unknown at the time of evaluation being done (Dehjia and Wahba 2002). This is known as missing value problem because O^T and O^C cannot happen simultaneously.

There have been substantial discussions on the evaluation designs and methods to find unbiased estimates of the unknown outcomes and hence impact (Baker 2000, Ravallion 2008). The main designs for impact evaluation include randomization or experimental method, nonexperimental and

[1] In the impact evaluation literature, the term ‘comparison group’ is used in case of non-experimental and quasi-experimental designs and ‘treatment group’ is used in experimental or randomised designs.

quasi-experimental designs, reflexive comparisons, double difference or difference-in-differences method, and instrumental variables method. *Randomization* or experimental method selects the treatment and control groups randomly within some well-defined set of people. This implies that there should be no difference (in expectation) between the two groups besides the fact that the treatment group had access to the intervention programme. There can still be differences due to sampling error; the larger the size of the treatment and control samples the less the error. *Reflexive comparisons*, in which a baseline survey of participants is done before the intervention and a follow-up survey is done after. This means that the data are compared to the same individuals after project implementation (Jalan and Ravllion 2003). The baseline is regarded as the control group and follow-ups as the treatment groups, and impact is measured by the change in outcome indicators between baseline and follow-ups (Kerr *et al*. 2002). This is a single difference method of impact evaluation design. *Double difference or difference-in-differences (DD)* methods compare a treatment and control group (first difference) before and after an intervention (second difference). In other words, there are both control and treatment groups during the baseline and follow-ups. Thus the DD method is the extended version of the reflexive comparison and can be extended to higher order differences.

(2) Evaluation design

KHETI was an action research project and so ex-post evaluation was considered an important component and the design was chosen carefully to identify the actual impacts of the intervention. Two surveys were carried out in the Sironj Block; the first in July 2008 is the baseline, before the intervention which was started in August 2008; and the next follow-up survey was carried out in March 2009, approximately 8 months time from intervention. Thus the surveys produced both longitudinal and cross-section data sets but the gap between the two surveys is too short to evaluate longer term impact, rather is possible to compare immediate outcomes of KHETI project.

Both surveys (baseline and after intervention) include a control group along with the treated, and used structured questionnaire to interview selected farmers. The block has altogether 225 villages and there were a total of 698 active shareholders of SCPCL in 30 of the villages; all of them were interviewed. They are the beneficiaries of KHETI. The control group was chosen from non-SCPCL villages. The initial thought was to include a matching group of 698 non-member farmers. Due to multifarious constraints such as limited time, unfavourable climate and limited resources 507 non-member farmers from 26 non-SCPCL villages were interviewed. This sample was selected as follows. Out of 225 villages 150 have no interventions from SCPCL or any other NGO. From the list of these 150 non-SCPCL villages, 26 villages were selected randomly, which is around 18% of the non-SCPCL villages in the block. From each non-SCPCL village, 20 to 25 farmers (ie. households) were chosen for interview. In percentage term 20 to 100% of the families from the selected villages were included in the non-member sample. The villages of Sironj are small with a maximum number of 100 families in some of the villages. Some of the villages are very small. Either 'all households' from the small villages were included for interview (100%), or most of the households were chosen; from relatively larger villages households were chosen randomly. The non-member farmers are selected such that they are not beyond the ranges of age, own land and per capita income of the members of SCPCL, and so groups are somewhat matching in terms of major characteristics but numbers are different: 698 member farmers and 507 non-member farmers.

The study used a double difference design; both treated and control groups were interviewed before the intervention with a follow-up nearly one year after. Due to randomisation, the difference between treated and non-treated groups is expected to be unbiased estimate of true impact. However, as in other social experiments, it is not possible to control for all characteristics that may systematically influence outcome variables. So it is necessary to check the robustness of impact.

(3) Data description

The survey uses structured questionnaires collected by trained local survey assistants via personal interviews. English version of the questionnaire was translated into local language. Socioeconomic profiles of the sample are presented in Table 1. Apparently, sample appears to be biased towards male. This reflects Indian farming context; the occupation is usually dominated by males. The male members are primarily responsible for farming and so they are the shareholders of SCPCL, though they are assisted by their female counterparts. Most of the female members were located in a particular village because of the ethnic nature of the community in that village with female dominance. Mean age of sample producers is around 39 years with a median of 35 years. About 50% of the farmers are illiterate. Majority belong to backward caste. With respect to age, education and annual income, the difference between non-member and member/shareholder categories is negligible. There are variations in terms of gender, marital status and caste. The groups are statistically the same in terms of own land though members have significantly higher access to encroached and leased land and their human capital for agriculture is significantly higher. Average land ownership of the sample farmers is 3.09 acres, lower than the MP average. The treated farmers owned from 0 to 35 acres of land and the non-treated farmers owned from 0 to 32 acres. Some landless families are included in both groups. Primary occupation of more than 97% of them is agriculture, others are mainly labourers. However, the average income of both groups of farmers is much higher than the median indicating inclusion of a few farmers in the sample with excessively higher income than the average.

[INSERT Table 1 HERE]

(4) Impact indicators

Both quantitative and qualitative indicators can be used to measure the direct and indirect impact of the mobile phone technology on the extension services delivery and on farmers' knowledge, awareness and attitude to new technology. More common quantitative measure could be productivity.

Adoption rate of a particular technology due to a specific extension approach like the farmers field school is also a widely used indicator. Other indicators such as farmer's knowledge, attitude, awareness and contact intensity are also used to measure the impact. Increased knowledge and awareness are generally considered prerequisites to the adoption of new practices and technologies. Changes in knowledge, attitudes, skills and aspirations lead to changes in practices, which in turn cause the desired change in production and therefore income of the farmers. The variables like knowledge, awareness, and aspirations have no rigid definitions and are difficult to measure but not impossible. For example, Erbaugh et al. (2001) measured farmer's knowledge about integrated pest management (IPM) using an index constructed from rated attributes. There could be more indicators (van den Berg and Jiggins, 2007). For example, the FFS curricula often have been designed to enhance farmers' educational, social, and political capabilities. In our case, ICT technology was designed such that member farmers of SCPCL can get a broad range of information on time, with adequate speed and quality. We would expect immediate gains from the initiative directly on the quantity, speed and quality of extension services, and indirectly on farmers' knowledge, awareness, and attitude towards using extension services as well as farm practices and technical know-how. Farmers would be expected to use timely information on seed, fertilizer, pesticides and prices to improve their welfare.

Awareness and knowledge were conceptualised as follows. Farmers were asked to rate their perception on 4 attributes such as agricultural knowledge, new practices /technology, funding to use the knowledge and funding for basic agricultural activities on a scale of 0 to 5; 0 indicated no perception and 5 indicated high perception. Farmers were allowed to answer the related questions from self-perception. Details of the questions to construct the index are given in Appendix 1. These four component attributes represent four types of awareness and knowledge with the maximum of total scores equal 20 (=4X5). With these data we constructed an awareness-knowledge index (AKI) using a general formula giving equal weight to each attribute as follows.

$$O_i = \frac{\sum_{j=1}^{J} O_j}{S} \qquad (2)$$

Here, O is outcome in general, i represents sampling units (member and non-member farmers), j=1, ..., J. J is the total of component attributes (4 in case of AKI), S is the maximum limit of scores a farmer can have (20 in this case of AKI). So the values of AKI range from 0 (indicates no awareness/knowledge) to 1 (maximum possible awareness/knowledge). We also constructed separate indices for each of the four component attributes of AKI and in such cases the maximum limit of scores for each attribute was 5 and the index for an attribute ranges the same from 0 to 1.

The surveys included some questions related to direct impact such as speed, quality and quantity. In addition to descriptive analysis, we constructed a quality index (QI) as an outcome indicator to measure impact using the same formula and a quality related question, details of which are given in Appendix 1. The farmers were asked to score the quality of the services of all providers on a scale of 1 being the worst quality and 5 being very good quality. There were eight sources other than *Munnas*. Farmers used these other sources before the intervention. The government services appeared the worst and the *Munnas* are the best of quality. As for an individual source, the scores ranged from 1 to 5. The sum of the scores from 8 sources before the intervention ranged from 8 to 40. We standardized the scores of both before and after situations into positive numbers up to a maximum of 1. This is done using the same method as in equation (2).

(5) Empirical estimation strategy

In the double difference framework, the impact in equation (1) can be rewritten as:

$$\bar{I} = \frac{1}{n}\sum_{i=1}^{n}[(O_{i1}^{T} - O_{i0}^{C1}) - (O_{i1}^{C2} - O_{i0}^{C2})] \quad (3)$$

Where, C1 is the treated group before the intervention, C2 is the non-treated control group, the subscript '0' denotes baseline and the other subscript '1' stands for after intervention. We would expect equation (3) to produce unbiased impact due to randomisation, but due to the nature of social experiment we do not rule out the possibility of systematic differences between the groups and so examined the robustness of the impact using regression analysis as follows:

$$O_i = \alpha + \beta_k \sum_{k=1}^{K} X_{ik} + \gamma ICT_i + \partial V + u_i \quad (4)$$

Where O_i is outcome variable of interest, such as farmers' agricultural knowledge, adoption of the agricultural technology, speed of delivery of extension services, quantity/quality of services, yields or welfare; X_i is a vector of farmer specific characteristics variables; V_i is a vector of village specific factors, u_i is random error with usual properties. ICT_{it} is an indicator variable for ICT-enhanced agricultural extension services. Because KHETI services targeted all member farmers of SCPCL but not non-member farmers, ICT equals 1 for SCPCL members in t=1 (post-intervention) and 0 for the rest[i]. The farmer and village specific characteristics variables are chosen based on the common practice of rigorous impact studies as well as parsimony. Highly insignificant variables were dropped from the model, assuming that such variables will not cause omitted variable problem. Definition and descriptive statistics of the variables are reported in Appendix 2. Of course, spillover effects are to be expected because information travels from farmers to farmers and other means of communication. As non-members are located in different villages in this mountainous area, we would expect low spillover impact. We also report some reflexive comparisons, because some of the impact related questions were not applicable to the non-treated units.

V. RESULTS

(1) The direct effect of ICT intervention: speed, quality and quantity of services

In this section we analyse the direct impact of KHETI intervention on extension services delivery. Reflexive comparison is used, because KHETI was meant for members and so some impact questions in the final survey are applicable only to them. A descriptive analysis is presented in Table 2. Majority of the farmers rated the new technology more useful, faster and of better quality. Farmers were using more services than they used before the project. More than 75% of the farmers view mobile phone assisted services useful, more than 86% view KHETI services faster and 13% view it much faster than the other services that farmers had prior to the introduction of this innovation. Around 96% of the farmers were using more agricultural advice after they were exposed to innovation. About 88% of the farmers view the extension services are of better quality compared to the services they received before. The average estimated quality index (QI) increased from 0.57 before the intervention to 0.92 after the intervention. Thus the treated farmers judged the new service far better than the existing services; the gain was 61% higher than the previous services. In general, it appears that the impact of information technology was prominent in quality of extension services. Of course, the possibility of overstatement of the quality of the ICT-enhanced services cannot be ruled out. The services were initially delivered free of cost. Farmers might have expected continuation of the service similarly if they could present the benefit more powerfully. However, even if we assume some degrees of exaggeration, still the new method of service delivery would be a significantly higher quality-enhanced technique.

[INSERT Table 2 HERE]

We further assessed the impact on services quality while controlling for some farmer- and village-specific characteristics. Table 3 reveals the multiple regression results. Due to the nature of the dependant variable (QI), which ranges from 0 to 1, we use Tobit model for estimation, because OLS may not produce consistent estimate for censored dependent variable (Cameron and Trivedi 2009).

Nevertheless, we report both Tobit and OLS estimation results for robustness check. Regression specification error test (RESET) suggests that there is no significant error in model specification[ii]. White heteroskedasticity-corrected estimates are employed since a significant heteroskedasticity was detected (Breusch-Pagan Chi_2=33.66, prob>Chi_2=0.00). The estimated effect of ICT on the quality of services is positive and statistically significant at 1% level. The results are consistent and robust across different models and specifications. The magnitude of the estimated coefficient of the ICT variable is 0.42 in the Tobit model, suggesting that the quality of services is 0.42 units higher due to the use of mobilephone technology. Given the mean QI of the treatment group before intervention at 0.57, this suggests an increase of 74% in overall quality after the introduction of KHETI intervention. The OLS estimate was smaller but still the QI due to ICT was 0.35 units higher than the services without ICT, suggesting a 61% increase after the intervention.

Other significant factors are age of farmers, land rental, irrigation and agricultural assets. Land rental and access to irrigation facilities affect quality of the extension services negatively. Those renting might have put less effort to obtain quality extension input due to disincentives arising from sharing or leasing arrangements. Those renting out are not directly involved in cultivation and so might get less attention from extension agents. Landlords may be relatively more influential to obtain existing pre-intervention extension services. Farmers with irrigation facilities are expected to be more aware of improved practices and might have access to relatively better extension services before the introduction of ICT enhanced services. Farmers who own agriculture assets appear to have received higher quality service partly because they made more efforts in seeking extension services that are relevant and useful to them. Marital status is marginally significantly associated with the quality of the services the farmers receive suggesting social factors like marital status may influence service delivery. This may be more relevant for adult women in India. Often unmarried/single/widow are discriminated due to social attitude. Extension people may find it easier to communicate with a married person than a single.

Village level characteristics also appear to be associated with services quality farmers received. Farmers in villages with better infrastructure such as access to buses and electricity have reported higher services quality than farmers in villages without access to these infrastructures. However, farmers is richer villages appear to be slightly less happy with the changes in services quality than farmers in poorer villages although the magnitude of the estimated coefficient is almost negligible. This may also be affected by some psychological factors, for example, farmers in richer villages have a higher expectation and standard for the services they receive.

[INSERT Table 3 HERE]

Quality is often categorised into technical and functional. In regard to mobile phone technology, technical quality may refer to the network coverage, bandwidth, network congestion, voice quality, data transfer delay, network security, data loss rate, software reliability, reliability of data transfer and efficient service restoration (Siau and Shen 2003, Wee and Guitierrez 2005). Functional quality refers to the reliability, responsiveness, access, communication, security, accuracy and specificity of information, ease of use, affordability, availability and access. Quality can also be reflected in the frequency farmers demand queries to the Munnas and how promptly they are answered. Farmers are hence asked about this information in the evaluation. Table 4 reports the comparisons of the frequency of queries raised by farmers and the speed of answers they receive before and after the KHETI intervention. We note a considerable increase in the demand for services. As baseline survey identified, more than 89% of the member farmers had no queries to SCPCL. All of them however, according to the final survey, had queries to get answered. Some farmers (6.5%) were even asking for information many times in a week supporting farmers' augmented thirst for agricultural knowledge, practices and information. The mobile technology also helped to deliver the services quickly. In their responses to the question ‘how long does it take SCPCL/*Munnas* to answer your queries?’, only 5% of members reported a quick response during the initial survey before intervention, and this proportion was increased to 37% in the final post-intervention survey. Answering the queries within a day increased from 2% to 31%. This indicates a massive improvement in the communication between farmers and SCPCL.

[INSERT Table 4 HERE]

(2) Indirect effect of ICT intervention: Impact on farmers’ awareness, knowledge and attitude

Table 5 compares the awareness-knowledge indices (AKI) of the treatment and control groups. Part A of the table reports the basic descriptive statistics and the differences between the treatment and control groups. Part B reports the differences in AKI before and after the intervention in both groups and the double difference calculation results. As part A shows, the average value of the AKI was the same (0.68) for both the groups before the project being implemented. As expected, the gap between the groups increased after the intervention. AKI for the treatment group increased from 0.68 to 0.72 and is statistically significant at the 1% level, while the change for the control group was only from 0.68 to 0.69 and is not statistically significant. A disaggregated analysis of the four attributes of AKI gives us striking evidence. At the baseline, there were some significant differences between the groups with respect to three of the four attributes: the non-treated group was slightly better at agricultural knowledge and new practices/technology; while the treatment group is better in knowledge on funding for basic agricultural activities.

However, after the intervention, the treatment group has caught up with the control group in new agricultural practices and technology. There is no significant difference between the two groups in this respect. The gap in terms of agricultural knowledge also narrows down from 0.04 to 0.03 units.

Moreover, the treatment group has surpassed the control group significantly on knowledge in funding information and strengthened its lead in knowledge on funding for basic agricultural activities. The gaps between the two groups increased to 0.06 and 0.10 in these two areas, respectively, and are statistically significant at the 1% level. From the reflexive comparison, the gains for the treatment group are significant in 3 out of the 4 attributes and in overall AKI index at the 1% significance level. On the contrary, the changes within the control group over the same time period were neither big nor significant. All these provide evidence in support of the positive impact of the mobile phone technology-assisted extension services on farmers' knowledge and awareness. Double difference impact calculated using equation (3) is 0.04 units for overall AKI index, and are 0.02, 0.04, 0.05 and 0.04 units for the four attributes, respectively. This is not a small impact given the short length of intervention. Given the mean AKI of the treated group was 0.68 on a 0 to 1 scale, this suggests a 3.7% net increase in AKI over the short eight months due to the employment of the mobile phone technology.

[INSERT Table 5 HERE]

Regression analysis: impact on awareness and knowledge

Since there are still some difference in farmer and village characteristics between the treatment and the control groups, we use regression analysis to control for some of the systematic differences in farmers and villages which the survey design cannot fully control. In order to eliminate the possible influence of time trend and other external factors which are common to both the treatment and control groups, following the double difference research strategy, we use the pre- and post-intervention changes in AKI as the dependent variable and examine the difference between the treatment and the control groups in their changes in AKI. In the model, we control for household characteristics in the base model and control for farmer and village level characteristics in the full model. We use primary and middle school education alternatively to proxy human capital in the farmers. The regression specification error test (RESET) suggests that the full model is preferred to the base model [iii] . A significant heteroskedasticity was detected (Breusch-Pagan Chi^2=17.23, prob>Chi^2=0.00) and hence we use White heteroskedasticity-corrected estimates. Table 6 reveals the results. The results are robust across different models.

[INSERT Table 6 HERE]

The estimated effect of ICT on awareness is 0.047 units without village level fixed effects. The estimated results of the full model report greater impact of ICT intervention, which is 0.071 units. In other words, holding farmer and village specific characteristics constant, given the mean awareness index of the treatment group before the intervention which was 0.68, the eight months intervention has led to an increase in farmers' knowledge and awareness by 10.4%. The estimated coefficients for the model using primary education as control variable yield consistent results. In sum, all the estimated coefficients of the ICT impact variable are positive and statistically significant at 1% level across different models and specifications. This confirms that the technology designed in the KHETI project was able to enhance knowledge and awareness of the farmers in the project area.

As regards the control variables, older farmers appear to have greater knowledge and awareness in agriculture techniques and information. The negative sign of the gender variable reflects lower visibility of women in agriculture, may be due to social barrier in the Indian context. Women's engagement in agriculture is usually a hidden matter and it is difficult for them to get access to information before the male farmers. Interestingly, the estimated coefficient of the primary education variable is negative and marginally significant suggesting that the KHETI intervention has brought more increase in knowledge and awareness for illiterate farmers than for farmers with primary education. This indicates that such mobile phone technology enhanced agricultural extension services has benefited more of those poorest farmers than the relative better off farmers. Poorer farmers are more disadvantaged without project and naturally they gain more from being exposed to intervention. The estimated coefficient of middle school education is positive but not statistically significant. This is not surprising because only less than 10% of the farmers have middle school education and these group of educated farmers usually are able to find solutions to basic farming problems themselves.

Farmers who own land gain less than those who do not own land. This again suggest that the gains from the KHETI project benefits those disadvantaged more than those relatively better off. Similarly, farmers who have encroached land benefit more in terms of agriculture knowledge and awareness than those who have not. Socio-economic status measured by caste categories does not appear to be significantly associated with the short-term changes in AKI reported by the farmers. Farmers who have access to credit appear to have less increase in AKI than those without access. This is again consistent with the findings earlier on education and landownership, suggesting that poorer farmers which are normally disadvantaged gain more from being exposed to the intervention. Farmers who have access to radio and television appear to have greater knowledge and awareness to agricultural knowledge, new practices and funding sources. The estimated coefficients of the village infrastructure variables are both positive and significant as expected. Again farmers in richer village reported less increase in AKI after the intervention probably because of their better awareness and knowledge before the intervention and that the KHETI project benefits the disadvantaged community more than those better off community.

(3) Impact on farmers' attitudes

The impact of KHETI project on farmers living in remote rural area is more than the direct effect on the speed and quality of services delivery and on their knowledge on agricultural technology and information. The experience of using mobile phone technology assisted agricultural extension services may have also opened up the mind an vision of these farmers about modern technology and the changes in the external world and their relevance to their farming and life in general. In the evaluation, we have asked the farmers whether they "think the experience of using KHETI make you [farmers] try more new technology for agricultural production" and whether they "think the experience of using KHETI make you [farmers] try more new technology and new ways of life in the future". Summary of the survey results are reported in Table 7. About 99.4% of the surveyed farmers replied "yes" to the first question and 99.1% replied "yes" to the second question. Although we recognize that there may be some psychological factors making the farmers more intend to give a positive answer in the hope to continue to receive such free extension services, all this suggests the wider and deeper impact of the ICT-enhanced intervention on farmers' attitude and aspiration to life and to future.

[Insert Table 7 here]

VI. CONCLUSIONS

This study examines the impact of an innovative mobile phone technology-assisted agricultural service delivery system (KHETI) for poor and marginalised farmers in Madhya Pradesh of India. The project provides speedy communication of audio-visual dialogues between farmers and agriculture experts through local youths called *Munnas* and special mobile phone technology. It aims to solve the problem in reaching all the members of SCPCL with timely extension services. This evaluation of KHETI system is based on randomized survey data collected through structured questionnaires before the intervention and approximately 8 months after. Immediate impacts on speed, quality and usage of the services and on farmers' awareness and agricultural knowledge are assessed. Particularly, two indices such as Quality Index (QI) and Awareness-Knowledge Index (AKI) comprising agricultural knowledge, awareness of new practices and knowledge of funding sources were constructed to represent immediate outcome and measure the impact of information technology.

Our evidence demonstrates that farmers gained knowledge and awareness after being treated by the innovative mobile phone technology and *Munna* services. The gain was 10.4% under the most controlled evaluation; positive and significant. Farmers assessed the quality of the services around 0.42 units (74%) higher than what was available before the ICT enhanced services. More than 75% of the farmers view mobile phone assisted services useful, more than 86% view *Munna* services faster than the agricultural services that were accessible prior to the introduction of this innovation. More than 96% of the farmers were using more agricultural advice after they were exposed to innovation.

Moreover, the experience of using this mobile phone technology assisted extension services has made farmers feel more at ease with new technology and adapting to new things for life in the future. Admittedly, the longevity of farmers' attitude towards e-services is subject to continued examination, especially with ongoing evolution and revolution. Historically, any successful new technology has always created its own set of applications that do not exist when it was conceived and similarly when mobile phone technology was invented, poor farmers did not know that they could use them for learning new agricultural knowledge that they require to improve their way of life. The experience of using KHETI to certain extent opened farmers' mind regarding the relevance of modern information and communication technologies to their production activities and their life.

Another crucial finding from this research is that our evidence indicates that the disadvantaged farmers and poorer communities gained more from this ICT-assisted intervention than those who are better off. There may be some misunderstanding that modern technologies such as ICT benefit only the rich and the educated, but do not really work for the bottom of the pyramid. The developmental goal of technological advancement may not reach the community that are most disadvantaged. Evidence from the KHETI project suggests that ICT-assisted intervention can generate significant developmental effects for the poor. This achievement of the project may be to certain extent due to the choice of an appropriate technology, the mobile phone technology, instead of more advance networked internet system in the poorest part of India. This is a useful lesson that we can learn from the KHETI experience for future ICT or wider technology for development projects.

One of the fertile grounds for future research is to identify the improvement in farm practices, efficiency and competitiveness due to *Munna* services and so direct the innovation towards supporting efficient and competitive farm practices by the small and marginalised farmers. Moreover, it is important to identify which factors may influence the strength of the impact of ICT on the final outcome of intervention such as welfare. Appropriate policy would then target these factors to ensure better access of the disadvantaged groups to resources. The maximum success from an intervention like the ICT enhanced extension services delivery thus remains not only on the better method but also on the capacity of the target group to use information.

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Table 1. Socioeconomic profiles of the sample farmers/producers

Characteristics		Non-member (N=507)	Member (N=698)	Total (N=1205)
Gender %	Female***	3.2	18.3	12.0
	Male***	96.8	81.7	88.0
	Total	100.0	100.0	100.0
Age (years)	Mean	39.4	38.4	38.8
Education %	Illiterate	52.3	48.4	50.0
	Primary**	34.1	40.3	37.7
	Middle	8.7	7.9	8.2
	High School*	4.1	2.3	3.1
	Intermediate & Above	0.8	1.1	1.0
	Total	100.0	100.0	100.0
Marital status (N)	Divorced	1	1	2
	Married***	490	645	1135
	Unmarried***	4	25	29
	Widow	8	18	26
	Widower	4	9	13
Caste category (%)	General**	13.4	9.3	11.0
	Other Backward Caste	54.0	52.1	52.9
	Scheduled Caste***	23.9	36.7	31.3
	Scheduled Tribe***	8.7	1.9	4.7
	Total	100.0	100.0	100.0
Adult members (persons)	Per family***	2.15	2.35	2.26
Children (persons)	Per family*	2.56	2.41	2.47
Own land (acres)	Per family	3.17	3.03	3.09
Encroached land (acres)	Per family***	0.17	0.62	0.43
Leased in land (acres)	Per family***	0.04	0.51	0.31
Leased out land (acres)	Per family*	0.06	0.11	0.09
Persons available for agriculture	Per family ***	2.1	2.4	2.3
Primary occupation (%)	Agriculture***	95.3	98.9	97.3
	Labourer ***	4.1	0.7	2.2
	Other	0.6	0.4	0.5
Annual per capita income (Rs.)	Per family*	3492	4528	4277

Source: Questionnaire survey 2008.
Rs. is Indian currency Rupees (1 US$= Rs. 48.8 during the survey in November 2008);
T-test results of equal means between the member and non-member groups are reported as *** Significant at 1%, ** Significant at 5%, * Significant at 10% level.

Table 2. Impact of ICT intervention: usefulness, effectiveness and changes in quality and attitude

		Freq.	Percent
How useful *Munna* Services are	Very useful	118	16.9
	Useful	530	75.9
	Medium	48	6.9
	No use	2	0.3
	Total	698	100.0
Speed of services compared to before	Faster	604	86.5
	Much faster	90	12.9
	No change	4	0.6
	Total	698	100.00
Quality of services compared to old services	Better	611	87.5
	Far better	68	9.7
	The same	19	2.7
	Total	698	100.0
Effect of KHETI on quantity of services	Use more agri-advice	672	96.3
	Use less agri-advice	2	0.3
	No difference	24	3.4
	Total	698	100.0
Quality Index (mean)	Before intervention	698	0.57
	After intervention	698	0.92

Source: Questionnaire survey 2008 & 2009.

Table 3. Regression results: impact of ICT on quality of extension services

	OLS Model 1		OLS Model 2		Tobit Model 1		Tobit Model 2	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Adopted *KHETI*	0.350***	0.005	0.350***	0.005	0.418***	0.009	0.418***	0.009
Age	0.001***	0.000	0.001***	0.000	0.001***	0.000	0.001***	0.000
Area in acres rented in	-0.002*	0.001	-0.002*	0.001	-0.003*	0.001	-0.003*	0.001
Area in acres rented out	-0.007**	0.003	-0.007**	0.003	-0.009**	0.005	-0.009**	0.005
Tropical livestock unit	-0.003	0.002	-0.003	0.002	-0.003	0.003	-0.004	0.003
Farmer's gender	0.002	0.008	0.004	0.008	-0.002	0.011	0.002	0.011
Middle school	0.000	0.011	0.005	0.011	-0.006	0.016	0.001	0.016
Primary education	0.009	0.006	0.007	0.006	0.013	0.009	0.010	0.009
Backward caste	-0.014	0.009	-0.020**	0.010	-0.019	0.014	-0.026*	0.015
Schedule caste or tribe	-0.009	0.010	-0.010	0.010	-0.016	0.015	-0.018	0.015
Access to credit	0.005	0.006	0.010*	0.006	0.004	0.008	0.011	0.009
Marital state	0.021*	0.012	0.022*	0.012	0.026	0.016	0.028*	0.017
Irrigation facilities	-0.037***	0.010	-0.040***	0.010	-0.047***	0.013	-0.051***	0.014
Agricultural assets	0.015***	0.006	0.013**	0.006	0.022***	0.009	0.018**	0.009
Village has buses			0.013*	0.007			0.018*	0.011
Village has electricity			0.020*	0.012			0.036**	0.017
Village economy envir.			-0.001***	0.000			-0.001***	0.000
Constant	0.538***	0.018	0.530***	0.021	0.530***	0.026	0.514***	0.029
N	1336		1336		1336		1336	
OLS R^2/Tobit sigma	0.76		0.76		0.135***	0.004	0.134***	0.004
Log pseudolikelihood					221.82		232.20	

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. White heteroskedasticity-corrected robust standard errors are reported here.
Dependent variable is quality index.
Sample: the treatment group before and after the intervention.

Table 4. Questions asked to SCPCL/*Munnas* and speed of answering them

	Post-intervention survey		Pre-intervention survey	
	Freq	Percent	Freq	Percent
Frequency of queries				
Daily	3	0.43	0	0.00
Many times in a week	45	6.45	0	0.00
Once in a month	8	1.15	1	0.14
Once in a week	36	5.16	0	0.00
When Needed	606	86.82	73	10.46
Not asked any question	0	0.00	624	89.40
Total	698	100.00	698	100.00
Speed of answers to the questions				
Quick	258	36.96	35	5.01
1 day	217	31.09	13	1.86
2-4 days	134	19.20	6	0.86
5 days or more	7	1.00	4	0.57
No answer/not asked any question	82	11.75	640	91.69
Total	698	100.00	698	100.00

Source: Questionnaire survey 2008 & 2009.

Table 5. Descriptive statistics of farmer' awareness-knowledge indices

Attributes of awareness-knowledge	Non-member (Control group)		Member (Treatment group)		Difference between members and non-members	
	Mean	Standard dev	Mean	Standard dev	Dif. In mean	t-statistics
Part A						
Baseline 2008						
Agricultural knowledge*** (2.74)	0.73	0.21	0.69	0.28	-0.04	2.74***
New agricultural practices/ technology***(3.09)	0.70	0.17	0.67	0.24	-0.03	3.09***
Knowledge on funding information (0.60)	0.64	0.17	0.65	0.25	0.01	0.60
Knowledge on funding for basic agricultural activities***(3.52)	0.66	0.26	0.71	0.29	0.05	3.52***
Overall awareness (0.34)	0.68	0.13	0.68	0.21	0.00	0.34
Final survey 2009						
Agricultural knowledge*(1.85)	0.74	0.20	0.71	0.24	-0.03	1.85*
New agricultural practices/ technology (0.10)	0.71	0.16	0.71	0.19	0.00	0.10
Knowledge on funding information***(4.74)	0.64	0.17	0.70	0.21	0.06	4.74***
Knowledge on funding for basic agricultural activities***(7.08)	0.66	0.26	0.76	0.24	0.10	7.08***
Overall awareness***(4.28)	0.69	0.12	0.72	0.14	0.03	4.28***

Part B			
Mean difference baseline 2008 & final survey 2009	Non-member	Member	Diff-in-diff
Agricultural knowledge	0.01 (0.27)	0.02 (1.45)	0.02** (2.06)
New agricultural practices/ tech.	0.01 (0.39)	0.04*** (3.74)	0.04*** (4.54)
Knowledge on funding information	0.00 (0.44)	0.05*** (4.02)	0.05*** (4.94)
Knowledge on funding for basic agricultural activities	0.00 (0.29)	0.05*** (3.43)	0.04*** (4.54)
Overall awareness	0.01 (0.53)	0.04*** (4.32)	0.04*** (4.61)

Source: Questionnaire survey 2008 and 2009.
*** Significant at 1%, ** Significant at 5%, * Significant at 10; figures in parentheses are calculated values of absolute t ratio.

Table 6. Impact of ICT on changes in farmers' knowledge and awareness

	Model 1		Model 2		Model 3		Model 4	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Adopted *KHETI* services	0.047***	0.008	0.071***	0.011	0.048***	0.008	0.073***	0.011
Age	0.001*	0.000	0.001*	0.000	0.001*	0.000	0.001*	0.000
Number of persons in agr.	-0.005	0.004	-0.004	0.004	-0.005	0.004	-0.004	0.004
Area in acres owned	-0.004*	0.001	-0.003*	0.001	-0.003**	0.001	-0.003*	0.001
Area in acre encroached	0.007**	0.003	0.007*	0.004	0.007**	0.003	0.007*	0.004
Area in acres rented in	-0.001	0.001	0.000	0.001	-0.001	0.001	0.000	0.001
Area in acres rented out	-0.003	0.003	-0.002	0.003	-0.003	0.003	-0.002	0.003
Farmer's gender	-0.053***	0.009	-0.052***	0.009	-0.055***	0.009	-0.056***	0.009
Middle school education	-0.010	0.012	0.000	0.012				
Primary education					-0.009	0.009	-0.015*	0.009
Backward caste	0.009	0.013	0.010	0.014	0.009	0.014	0.010	0.014
Schedule caste or tribe	-0.003	0.014	0.008	0.013	-0.003	0.014	0.006	0.014
Access to credit	-0.019**	0.009	-0.019**	0.008	-0.019**	0.009	-0.018**	0.009
Has radio/TV=1	0.028	0.020	0.052***	0.019	0.028	0.020	0.053***	0.020
Village has bus			0.015**	0.007			0.016**	0.007
Village has electricity			0.075***	0.013			0.076***	0.013
Village economy envir.			-0.002***	0.000			-0.002***	0.000
Constant	0.005	0.021	0.001	0.023	0.005	0.021	0.004	0.023
N	1204		1204		1204		1204	
R^2	0.054		0.131		0.055		0.134	

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. Heteroskedasticity robust standard errors are reported here.
Dependent variable: difference in awareness-knowledge index before and after KHETI intervention.
Sample: Treatment and control groups.

Table 7. The impact of KHETI project on farmers' attitude and aspiration

		Freq.	Percent
Do you think the experience of using KHETI make you try more new technology for agricultural production?	No	4	0.6
	Yes	693	99.4
	Total	698	100.0
Do you think the experience of using KHETI make you try more new technology & new ways of life in the future?	No	6	0.9
	Yes	691	99.1
	Total	698	100.0

Source: The 2009 evaluation survey.

Appendix 1. Questions related to component attributes of knowledge, awareness and quality of extension services and methodology of constructing indices.

	Minimum score	Maximum score	Indices Minimum	Indices Maximum
Questions asked to the farmers : Do you feel which of the lack of the following a big constraint for you (rank from 0 to 5 low to high)?				
Agri knowledge	0	5	(0/5)=0	(5/5)=1
New agri practices / technology	0	5	(0/5)=0	(5/5)=1
Funding to use this knowledge	0	5	(0/5)=0	(5/5)=1
Funding even for basic agri services	0	5	(0/5)=0	(5/5)=1
Awareness-knowledge index (AKI)	0	20	(0/20)=0	(20/20)=1
Questions asked to the farmers : From your experience, how useful is the advice from different sources of agricultural information / advice? [1=very bad quality, 2=bad, 3=acceptable, 4=good, 5=very good]				
Munnas/SCPCL	1	5	(1/5)=0.2	(5/5)=1
Other NGOs	1	5	(1/5)=0.2	(5/5)=1
Other farmers	1	5	(1/5)=0.2	(5/5)=1
Government extension services	1	5	(1/5)=0.2	(5/5)=1
Family	1	5	(1/5)=0.2	(5/5)=1
Radio	1	5	(1/5)=0.2	(5/5)=1
TV	1	5	(1/5)=0.2	(5/5)=1
Newspaper	1	5	(1/5)=0.2	(5/5)=1
Any other	1	5	(1/5)=0.2	(5/5)=1
Quality index QI for Munnas	1	5	(1/5)=0.2	(5/5)=1
Quality index (QI) for other sources	8	40	(8/40)=0.2	(40/40)=1

Appendix 2. Description of variables

Variable	Definition	Mean	St Dev
ICT_2	Farmers adopted *KHETI* services	0.579	0.494
Aware	Awareness index measured as in equation 2	0.681	0.180
Noinag	Number of persons in household in agriculture	2.253	1.042
Ownland	Area in acres owned by the farm household	3.090	3.362
encroach	Area in acre encroached by the household	0.431	1.544
Rentin	Area in acres rented in by the household	0.310	1.973
Rentout	Area in acres rented out by the household	0.091	0.696
gender_1	Farmer's gender (female=1)	0.120	0.325
edu_4	Farmer has middle school education=1	0.082	0.275
edu_5	Farmer has primary education=1	0.377	0.485
Eduhipls	Farmer has high school education and above=1	0.041	0.198
caste_2	Backward caste=1	0.529	0.499
Scst	Schedule caste or tribe=1	0.360	0.480
Credit	Farmer has access to credit=1	0.552	0.498
Rdtv	Farmer has radio/TV=1	0.069	0.253
Busv	Village has access to bus=1	0.721	0.449
Electv	Village has access to electricity=1	0.841	0.366
Villeco	Village economy measured by the total number of sample farmers in the village have access to electricity, mobile phone and TV	26.47	20.74
Age	Age of farmer (years)	38.812	12.641
Tlu	Tropical livestock unit	1.195	1.294
mstat_2	Marital status, married=1	0.942	0.234
Irfac_2	Farmers have irrigation facilities=1	0.191	0.393
Agas	Farmers have agricultural assets=1	0.430	0.495

[i] We verify the ICT adoption in two ways. First, the farmers were asked how often did they ask questions and how long did it take SCPCL/*Munnas* to answer queries. 74 member farmers asked SCPCL before the intervention. All 698 farmers asked questions in the post-intervention final survey and 616 of them received answers for their queries. This indicates that all member farmers are adopters of KHETI technology. Non-member farmers are not provided with KHETI services. Second, another question was asked to both members and non-members such that whether they are covered by SCPCL/*Munnas*. None of the non-members said 'yes' in the final survey.

[ii] $F_{3,1314}$ = 0.26, prob>F=0.86 in the model with village level factors and $F_{3,1317}$ = 1.03, prob>F=0.38 in the model without village level factors.

[iii] There is no significant error in model specification with village level factors ($F_{3,1183}$ = 2.53, prob>F=0.06) but specification error is significant in the model without village level factors ($F_{3,1187}$ = 5.40, prob>F=0.00).